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Review

Review and Précis of Terrence Deacon's *Incomplete Nature: How Mind Emerged from Matter*

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Abstract: We review and summarize Terrence Deacon's book, *Incomplete Nature: How Mind Emerged from Matter*.

1. Introduction

Terrence Deacon, a UC Berkeley professor of biological anthropology and neuroscience, has written a fascinating study, *Incomplete Nature: How Mind Emerged from Matter* [1], in which he attempts to deal with issues such as values, purpose, meaning, from a scientific perspective. He also attempts to "first understand life, then sentience, then the human mind (p. 466) [2]" in terms of what he calls absentials, which he defines in terms of the constraints on physical matter as is described below. He also attempts to find an alternative to dualism that is compatible with canonical scientific thinking.

The book contains the paradox that something that is absent, in fact, gives rise to the most critical things for human existence, namely life and mind. We are presented with a Zen puzzle, like the sound of one hand clapping, but a puzzle that gets at the roots of what we are. This book is not an easy read, as the author warns us, but it is in my opinion well worth the effort. It is also not an easy book to review either, but I feel it is important to do so to encourage others to read it and wrestle with the ideas that it develops. This is why I have combined the review with a précis of Deacon's book so as to introduce his concepts in an easily digested format with the hope that the reader will read the entire

book. I do not claim to have understood all that he has written, but I have understood enough to know that it is an important book and worth the effort to read it and consider the challenges that it presents.

He describes his goals in modest terms when he writes, "My purpose … is not to explain the origin of life, but rather to get clear about the principles that must be understood in order to focus this research on the most relevant details (p. 447)." He also assesses his achievement in modest terms when he writes, "I don't claim to have accomplished much more than to have described a hitherto unexplored alternative framing of these enigmatic problems (p. 538)."

This last statement is the one passage of the book where I have to disagree. Deacon has given us a framework and a language with which to discuss the "enigmatic problems" that he has tackled and that fascinate so many of us. And I am certainly in agreement with these closing remarks of his:

> It is my hope that this glimpse of another scientifically rigorous, but not simplistically materialistic, way to view these issues will inspire others to explore some of the many domains now made visible …. Mind didn't exactly emerge from matter, but from constraints of matter (p. 538).

I believe that Deacon in critiquing the modus operandi of science, particularly reductive science, has made a giant step forward in integrating the physical sciences with the biological sciences, the social sciences, the humanities and philosophy to help us understand the nature of life and mind and their origin from inanimate matter. I believe he has entered the realm of what Kuhn [3] has termed revolutionary science. There is little doubt that the paradigm of reductive science does not and cannot explain the phenomena of life, sentience, mind, purpose, meaning and value. We have learned much about the operations of the physical brain, its neurons, its neural networks, its chemistry, and its bicameralism and yet we cannot connect these understandings with human behavior, human will and human spirituality. Part of the new paradigm that Deacon is developing is the notion that biology in addition to being a physical and chemical science is also a semiotic science in which meaning plays an essential role in understanding living systems.

The reader might question whether Terrence Deacon has the expertise to criticize science; to reject the paradigm of reductionism, in the no-holds-barred way that he goes about his analysis. As one reads his book one becomes more and more impressed with the depth of his knowledge in so many fields including classical mechanics, thermodynamics, statistical physics, and quantum mechanics and then there is his in-depth knowledge of the chemistry of life, genetics, evolutionary biology to which we can add neuroscience and linguistics. I am a scientist trained as a physicist who wandered into media ecology, linguistics and systems biology, but I take my hat off to Deacon whose depth and breadth of scientific knowledge is truly encyclopedic.

Basically, Terrence Deacon formulates in scientific terms, making use of the concepts of thermodynamics, morphodynamics and teleodynamics, an explanation of what so many of us have known intuitively that life, sentience and higher order human mental processes cannot be explained in terms of computations and cybernetic processes nor can biology be derived from reduced to or predicted from physics. "Computations and cybernetic processes are insentient because they are not teleodynamic in their organization (p. 536)." His emergent approach builds on and extends Maturana and Varela's [4] notion of autopoiesis and Stuart Kauffman's [5,6] idea of autocatalysis.

2. Defining Deacon's Terms

As has been indicated above Deacon introduces and makes use of a number of special terms, including constraints, morphodynamics, teleodynamics, "entential processes", and "absential features", all of which require defining. The first two terms have current currency but Deacon uses them in a special way and hence they need clarification as to how he uses these terms. The other three are neologisms that he has coined so we will need to define these terms in the way Deacon uses them in order to understand his project.

3. Ententionality and Entential Processes

Deacon defines entention in the following way:

The term "entential" is "a generic adjective to describe all phenomena that are intrinsically incomplete in the sense of being in relationship to, constituted by, or organized to achieve something non-intrinsic (p. 27)."

The term "entential" derived from intentional goes beyond the meaning of intentional to encompass those attributes that are characteristic of living things that are not found in inanimate matter and include such things as a sense of self, self-maintenance, self-preservation, purpose, goal-orientedness, end-directedness, function, reproduction, evolution, adaptiveness, subjectivity, value, and meaning or semiosis. Ententionality involves a living organisms behavior to preserve or maintain itself and to propagate its organization [5–7].

Deacon describes entential phenomena in the following way:

Entential phenomena include functions that have satisfaction conditions, adaptations that have environmental correlates, thoughts that have contents, purposes that have goals, subjective experiences that have a self/other perspective, and values that have a self that is benefited or harmed (p. 27).

Ententionality, a key idea in Deacon's incomplete nature paradigm, is mysterious and difficult to grasp as he himself admits:

What makes entential processes so cryptic is that they exhibit properties that appear merely superimposed on materials or physical events, as though they are something in addition to and separate from their material-physical embodiment (p. 57).

Deacon links ententionality, as we will discover, to two more of his key concepts namely constraints and absentials (or absential features).

4. Constraints

Constraints are related to absences in the sense that they prevent certain things from happening. Although constraints reduce the number of possibilities they do not causally determine things either. Constraints are essential to Deacon's description of biotic systems. They bear a similarity to the constraint of the cylinder in an internal combustion engine which forces the energy released in the explosion of the gasoline vapor and air mixture to pushes against the piston and thus convert the energy released to do work that can be converted into the motion of a vehicle. Constraints are required

in a living organism so that it can convert the energy it extracts from its environment into the work necessary for its metabolism, growth, and reproduction, *i.e.*, the propagation of its organization. Instead of the energy being dispersed equally in all directions the constraint of the cylinder forces the energy to push against the piston.

> The term constraints thus denotes the property of being restricted or being less variable than possible, all other things being equal, and irrespective of why it is restricted …. Constraint is a property of a collection or ensemble of some sort, but a negative property. It is a way of referring to what is not exhibited, but could have been, at least under some circumstances (p. 193).

As we will soon discover there is an intimate relationship between constraints and information.

5. Absentials or Absential Features

Deacon contends that one cannot relate the phenomena of "a function, reference, purpose, or value" to physical matter and each of these phenomena "is in some way incomplete (p. 2)". "Longing, desire, passion, appetite, mourning, loss, aspiration—all are based on an analogous intrinsic incompleteness, an integral without-ness (p. 3)." Each of these phenomena cannot be explained in physical terms or linked to physical processes which is why Deacon suggests that there is something missing which he labels as an "absential" or an "absential feature (p. 3)", his neologism for what is missing from our understanding of the physical dimension of these phenomena. Absential features are the "defining property of life and mind (p. 3)."

There is another kind of absence that Deacon deals with namely the absence from scientific consideration for subjective things such as beauty, values, ethics, thought and consciousness. "Our scientific theories still have to officially deny them anything but a sort of heuristic legitimacy (p. 12)…. [They] have failed to explain what matters most to us: the place of meaning, purpose and value in the physical world (p. 22)."

Deacon's formulation of the absential represents what McLuhan would call a figure/ground reversal in which instead of focusing on matter one focuses on their interactions or as Deacon puts it:

> A counterintuitive figure/background reversal, focusing on what is absent rather than present, offers a means to repair some of the serious inadequacies of our conceptions of matter, order, life, work, information, representation and even consciousness and conceptions of value …. It requires reframing the way we think about the physical world in thoroughly dynamical, that is to say, process terms, and recasting our notion of causality in terms of something like the geometry of this dynamics, instead of thinking in terms of material objects in motion affected by contact and fields of force (p. 44).

Deacon suggests that organization be thought of in terms of constraints or what is not there: absences.

> But although the specific absences that constitute a constraint do not suffer the epiphenomenality of descriptive notions of organization, they are nevertheless explicitly not anything that is present. This requires that we show how what is absent is responsible

for the causal power of organization and the asymmetric dynamics of physical or living process (p. 195).

Elsewhere he writes, "Intrinsically emerging constraints are neither material nor dynamical—they are something missing—and yet as we have seen, they are not mere descriptive attributes of material processes either (p. 535)."

At the very end of his study Deacon for my mind nails his concept of the absential when he writes, "There is more here than stuff. There is how this stuff is organized and related to other stuff (p. 544)."

6. Morphodynamics

The standard definition of morphodynamics is "of or pertaining to dynamic changes in morphology (en.wiktionary.org) [8]". Deacon uses the term in a special way to connote the process of self-organization as is the case in which Bénard cells form or self-organize when a thin liquid layer is constantly heated from above or cooled from below. He (p. 193) points out, as has Kauffman, that life depends of extracting energy from the environment and by making use of constraints that are built up "by morphodynamic action (p. 541)" to use that energy to create the work needed for metabolism and reproductions. "Constraints don't do work, but they are the scaffolding upon which the capacity to do work depends (p. 419)."

Life therefore depends on the construction of constraints by morphodynamics or self-organization as is described by Deacon.

> Evidence that life involves morphodynamic processes comes from two attributes that are characteristic of all organisms. First, organisms are incessantly engaged in processes of creating and maintaining order. Their chemical processes and physical structures are organized so that they generate and maintain themselves by continually producing new appropriately structured and appropriately fitted molecular structures. Second, to accomplish this incessant order generation, they require a nearly constant throughput of energy and materials. They are in this respect dissipative systems. Together, these two characteristics give life its distinctive capacity to persistently and successfully work against the ubiquitous, relentless, incessantly degrading tendency of the second law of thermodynamics. Individual organisms do this via metabolism, development, repair, and immune response (p. 265).

Morphodynamic processes unlike thermodynamic processes, which dissipate or randomize order, actually create order, as is the case with Bénard cells. Deacon argues that biological systems rely on a special form of interdependency between complementary morphodynamic processes in order to generate their constraints internally (see Teleodynamics below). To exemplify this he develops a simple and empirically testable molecular model involving two morphodynamic processes, which are ubiquitously present in all organisms, namely the self-assembly of cellular membranes and the autocatalysis of organic compounds so essential to life and its ability to reproduce itself.

7. Teleodynamics

One of the key new ideas that Deacon introduces in his book is the notion of teleodynamics, which is essentially the key property that defines a living organism or a self that acts in its own self-interest.

> Even organisms as simple as bacteria have properties that qualify them as selves …. Issues of teleology, agency, representation, and value are critical elements of self that need to be considered …. [Teleodynamics is] "the core property which links the selves of even the simplest life forms with that seeming ineffable property that characterizes the human experience of self (p. 466, p. 468).

> Because organisms are teleodynamic systems, they do not merely react mechanically and thermodynamically to perturbation, but generally are organized to initiate a change in their internal deficits (p. 487).

An organism has choice. Its reaction to external stimuli is based on what is best for it. Non-living things have no choice, the best they can do is self-organize as is the case with crystal formation or the phenomenon of the Bénard cell.

> Teleodynamics was defined as a dynamical organization that exists because of the consequences of its continuance, and therefore can be described as being self-generating over time. But now consider what it would mean for a teleodynamic process to include within itself a representation of its own dynamical final causal tendencies …. The whole produces the parts and the parts produce the whole. But then a teleological process in which one critical dynamical component is a representational process that interprets its own teleodynamic tendency extends this convoluted causal circularity one level further (p. 526).

As Deacon points out morphodynamics or self-organization does not create a self, *i.e.*, an individual that acts in its own interest. This requires a third level of dynamics, teleodynamics, which depends on morphodynamics. "Teleodynamics can be understood as characterizing the distinguishing dynamics of life (p. 275)."

> The dependence of teleodynamic on morphodynamics and morphodynamics on thermodynamics constitutes a three-stage nested hierarchy of modes of dynamics, which ultimately links the most basic orthograde process—the second law of thermodynamics—with the teleodynamic logic of living and mental processes (p. 276).

> The core hypothesis of this book is that all teleodynamic phenomena necessarily depend upon, and emerge from, simpler morphodynamic and homeodynamic [*i.e.*, thermodynamic] processes (p. 487).

Deacon suggests that the interdependent combination of two morphodynamic processes, namely that of autocatalysis and the crystal like "self-assembly" such as produces viral shells or cell membranes, can produce a simple form of molecular teleodynamics. Because of its simplicity he suggests that this may even be a potential mechanism for how life might have emerged. Deacon claims that autocatalysis by itself cannot give rise to a living entity because while it is self-promoting it is not self-regulating or self-preserving (p. 295). A second feature is required, namely, self-containment. The self-organization of organic chemical structures that form the cell's membrane and provide

containment is similar to the way crystals form. "Containment creates physical individuality (p. 296) and is a necessary step for the creation of a "self", a living self, that can act teleologically in its own self-interest."

The trick is how to get these two morphodynamic processes, autocatalysis and membrane construction to co-emerge. They in fact form a reciprocal support for each other because both autocatalysis and the self-assembly of cell membranes are by themselves "self-undermining and self-limiting (p. 308)" as they are self-depleting processes. Deacon's solution to this problem is his suggestion that, these intrinsic limitations of autocatalysis and self-assembly processes are also a source of potential synergy. The conditions produced by each of these processes and their limitations together comprise a complementary and reciprocally supportive effect.

> The reciprocal complementarity of these self-organizing processes means that spontaneous linkage of autocatalysis with self-assembly containment is a possibility [that] creates the potential for self-repair, self-reconstitution, and even self-replication in a minimal form (pp. 304–306).

Teleodynamics is the essential ingredient that creates a living organism, a self that propagates its organization.

> The self-referential convolution of teleodynamics is the source of a special emergent form of self that not only continually creates its self-similarity and continuity, but also does so with respect to its alternative virtual forms. Thus autonomy and agency, and their implicit teleology, and even the locus of subjectivity, can be given a concrete account. Paradoxically, however, by filling in the physical dynamics of this account, we end up with a non-material conception of organism and neurological self, and by extension, of subjective self as well, a self that is embodied by dynamical constraints. But constraints are the present signature of what is absent. So surprisingly, this view of self shows it to be as non-material as Descartes might have imagined, and yet physical, extended, and relevant to the causal scheme of things as is the hole at the hub of the wheel (p. 484)."

8. An Alternative to Duality

Deacon contends that notions of duality as formulated by Descartes and others are essentially strategies to avoid the difficult question of how inanimate non-sentient matter became alive and sentient. Not overcoming the thinking of the world as stuff instead of process "leads to the idea that ententional phenomena are something above the physical and hence to dualism (p. 44)." It is also the case that, "ententional processes have a circular dynamics. Causality is in the dynamical organization. This is how something absent can make things happen (p. 45)." Deacon describes his program in the following terms: "Instead of trying to eliminate ententional properties from science, I propose we try to understand how they could have come into existence where none existed before. In other words, we start without any hint of teleos and end up with it, not the other way around (p. 138)."

Deacon's objective is to find an alternative to dualism as a way to deal with what seems to be the incompatibility of physical and mental phenomena.

Though people who have thought deeply about it intuit that it must ultimately be an incoherent idea, dualism is nonetheless deeply compelling. Why? The answer is simple: The causal logic of spontaneous physical processes is radically different than the ententional logic of life and mind. Efforts to deny this difference are as doomed to failure as are efforts to pretend that one or the other aspect is illusory. This difference is an essential fact to be explained, not explained away. But we can't stop at this dualistic appearance any more than at a dualistic metaphysics, because in all its cryptic forms, dualism is a halting move. It leaves all critical questions unasked (p. 140).

As we will see Deacon does not dodge, but asks those unasked questions and claims that he has found partial solutions to them or at least a start to addressing them. Towards the end of his exhaustive study he writes, "With the autogenic creation of self as our model, we have broken the spell of dualism by focusing attention on the contributions of both what is present and what is absent (p. 534)."

To my mind what Deacon has attempted to do is to knit together the analytic approach of reductive science and the synthetic approach of emergence theory, philosophy, the humanities, and the arts to understand the origins of life, the individual, sentience, consciousness, mind, thinking, knowledge, science itself, technology, design, purpose, agency, free will, intention, value, beauty, love, caring, and altruism. He wrote, "The problem of human subjectivity has turned out to be the ultimate 'hard problem of science' …. Because we have stubbornly insisted on looking for it where it could not be, in the stuff of the world (p. 535)."

His intention, as he describes it, is "to provide the scaffolding for a conceptual bridge from mechanistic relationships to end-directed, informational and normative relationships such are found in simple life forms [by exploring] a few of the implications for reformulating theories of work, information, evolution, self, sentience and value (p. 16)."

The Cartesian dualism that Deacon criticizes is substance dualism, the notion that there are two kinds of substance of which the world is constructed, namely physical substance (res extensa) and mental substance (res cogitans), the latter of which in Descartes systems includes God and soul. Deacon's system is actually one of property dualism in which there is just one kind of substance but there exist two distinct kinds of properties, physical and biological the latter of which also includes sentience and mind or in Deacon's terminology physical and ententional. Physical properties are described by thermodynamics and morphodynamics whereas ententional properties are described by teleodynamics, which in turn depend on morphodynamics and thermodynamics.

John Schumann and I [9] also adopted a property dualism in our paper "The Symbolosphere, Conceptualization, Language and Neo-Dualism" in which we wrote:

At our present level of understanding the only practical way to deal with understanding the nature of human mentality is to describe the activities of the brain on the one hand and of human thought and emotions which make up the human mind on the other hand and try where possible to find links between these two levels of phenomena, namely the physical brain and human thought and emotion.

Given the program that Deacon has developed I would now amend the above remarks to suggest that perhaps Deacon has provided a guide to understanding scientifically how one physical substance can give rise to distinct sets of properties, *i.e.*, the physical, which includes all of the physical world

and hence the bodies and brains (or organs of sentience for lower forms of life) and their physical activities, on the one hand, and, on the other hand, the ententional, which includes the life force, sentience, the human mind and its products, namely, language, culture, technology and science. Deacon's project is a work in progress but it represents, in my mind, a first step in cracking the mystery of how the physical world bifurcated into two different property domains, the inanimate non-teleological physical domain and the animate teleological domain of life, sentience and mind.

My central argument for interpreting Deacon's model in terms of property dualism is that he has shown that the same physical matter can have different forms of behavior and hence different properties. Following the logic of this argument I arrive at the following alternative interpretation that I would like to propose strictly as a probe ala McLuhan, which is rather than property duality Deacon's model is actually property triality. Deacon has suggested that there are three levels of matter interaction, namely thermodynamic, morphodynamic and teleodynamic processes. Each level of interaction gives rise to a different set of properties or behaviors of matter and hence I suggest that if Deacon is right (and I believe he is) then we are possibly dealing with property "triality" not property duality, with three distinct property domains of matter, namely,

(1) the thermodynamic dissipation of order as exemplified by an ideal gas;
(2) inanimate, non-self-maintaining self-organization (or morphodynamics) as exemplified by crystal formation and Bénard cells;
(3) self-organizing and self-maintaining systems as exemplified by all living teleodynamic organisms.

Invoking property duality or triality has an added benefit to help explain to those skeptics of emergence how a supervenient system can have properties not possessed by its components. Starting with substance monism we see that as a result of the three levels of dynamics, namely, thermodynamics, morphodynamics and teleodynamics that matter can behave in quite different ways depending on the ground in which it operates. Therefore although the stuff remains the same the property of the stuff depends not on its intrinsic properties but rather on the different ways that the stuff interacts with other stuff or with itself, *i.e.*, the ground in which it is operating. Is the way stuff A interacts with stuff B a property of A or a property of B or rather is it a property of their interaction which is not really a property of A or B but only of their interaction, *i.e.*, the "A-B interaction" The non-linearity of the interactions of the components of a supervenient system is no more mysterious than the non-linearity of quantum effects. And the phenomena of life, sentience and mind all involve the interactions of the valence electrons of atoms and free electrons whose behavior we know from quantum mechanics is totally non-linear. Non-linearity is the normal state of the world and linearity the exception not the other way around. Furthermore once one is dealing with non-linear interactions, which is the case when the number of components of a system exceeds two, one must invoke a figure/ground or field description rather than a linear cause and effect logic. Put in Aristotelian terms one cannot understand emergence in purely efficient cause terms but one must invoke formal cause and material cause from which emerges final cause in the case of teleodynamic systems.

Property duality might help resolve the concern of critics like Jaegwon Kim who argue that there is a double counting involved in the emergence model. They argue that the properties of the components give rise to the properties of the supervenient system as a whole, which then have a downward causal effect on the components so this is double counting. I believe that the reason their fallacy is "wrong", *i.e.*, there is no fallacy, is that they are working from an efficient cause perspective, namely, the idea that the fixed

properties of the components cause the supervenient system to behave as it does. This argument of the critics of emergence ignores figure-ground relationships. The properties of the components of the supervenient system depend on the ground they are operating in. To talk of their properties independent of the ground in which they operate is meaningless. Sodium does not have the property of mixing with chlorine to produce salt or *vice versa* chlorine does not have the property of mixing with sodium to produce salt. The property of sodium that matters is that it has an extra valence electron beyond its closed shell and, *vice versa*, the property of chlorine that matters is that it is missing a valence electron in its outer shell. The cause sodium and chlorine generate when interacting to produce salt is not efficient but formal, the form of their electron shells.

9. Potential Influence of McLuhan on Deacon

Deacon as mentioned above makes use of the Lao Tsu quote: "Thirty spokes converge at the wheel's hub, to a hole that allows it to turn (p. 18)." This parallels Marshall McLuhan's use of the same notion:

> Between the wheel and the axle there must be "play." This play is "touch." When the interval between wheel and axle is too small, they seize up and there is neither wheel nor axle. When the interval is too large, the wheel falls off … the resonant interval between the wheel and axle is where the action is (McLuhan's January 5, 1973 letter to Pierre Eliot Trudeau — McLuhan Collection in the Canadian National Archives and also a trope often used by McLuhan in his academic discourse).

The play or the gap is a form of zero, which the Hindus called sunya or "leave a space." Sunya was translated by Arab mathematicians into the term sifr from which we get cipher and then translated from the Arabic by the Italians into zero [10]. The gap is where all the action is according to McLuhan as is the case with a comic strip.

One of the aspects of Deacon's book that gave me additional pleasure were some of the parallels of his thinking with that of my former colleague at the University of Toronto, Marshall McLuhan. This is not without accident as Deacon in a private communication by email to me noted, when I pointed out these parallels, "McLuhan was an early influence on my thinking and probably has been a subliminal ground for my own development ever since …. Without question the f/g [figure/ground] reversal logic has been a hallmark of my own approach to the puzzles I have chosen to work on, and not just those discussed in Incomplete Nature, though this is where it is probably best developed."

Perhaps the greatest influence of McLuhan on Deacon is his use of f/g, McLuhan's shorthand for figure/ground, which Deacon writes as **figure/background**, and which appears no less than five times (p. 44, p. 192, p. 195, p. 373, p. 540) in his book. We have already encountered the quote on page 44 of Deacon's text in our discussion of absentials. His next use of f/g is his reversal of constraints and organization, where Deacon (p. 192) writes,

> paying attention to the critical role played by constraints in the determination of causal processes offers us a **figure/background** reversal that will turn out to be critical to addressing some of the more problematic issues standing in the way of developing a scientific theory of emergence (my bolding).

As we discussed earlier constraints give rise to something that is absent and since, as we will shortly see, constraints are information this is the sense in which information is about something absent as described in the following excerpt, which also brings in the reversal of figure and ground as it pertains to the notion of information:

> A complete account of the nature of information that is adequate to distinguish it from merely material or energetic relationships also requires a shift of focus, but the **figure/background** shift required is even more fundamental and more **counterintuitive** than that for energy. This is because what matters is not an account of only its physical properties, or even its formal properties. What matters in the case of information, and produces its distinctive physical consequences, is a relationship to something not there. Information is the archetypical **absential concept** (p. 373).

Note the use of two key McLuhan tropes in this passage, which I have bolded, namely, figure/ground and counterintuitiveness.

If I am interpreting Deacon correctly, I believe what he is saying is that organization, order and patterns are not intrinsic properties of matter but are the consequence of constraints, which as he says give rise to "what is not exhibited, but could have been (p. 193)."

Another f/g flip that Deacon makes is that of "thinking of regularity and organization in terms of possible features being excluded–real possibilities not actualized (p. 194)." The natural state of material things according to the second law of thermodynamic is maximum randomness or disorder. Regularity and organization are the results of constraints preventing the natural randomness to take place and hence organization due to constraints is a form of information [9]. And this gives rise to Deacon's contention that "what is absent is responsible for the causal power of organization (p. 195)."

Deacon also uses the f/g flip for constraints and order. To understand the figure of order one must consider the ground of constraints that give rise to the order.

> Something will tend to be assessed as being more orderly if it reflects more constraint. We tend to describe things as more orderly if they are more predictable, more symmetric, more correlated, and thus more redundant in some features. To the extant that constraint is reduced variety, there will be more redundancy in attributes …. The advantage of this negative way of assessing order is that it does not imply any model-based conception of order, regularity, or predictability … As we saw earlier, chaos theory provides an important context for demonstrating the usefulness of this **figure/background** shift in the analysis of order and organization (p. 195, my bolding).

By starting from the ground of constraints Deacon works his way around to the figures of "meaning, purpose or consciousness (p. 540)", as the following excerpt from his text explains.

> We began this exploration with an analogy between the challenged posed by the mathematics of zero and the challenge posed by the ententional properties of living and mental processes …. Then, accepting the challenge of explaining how it could be that absent phenomena might be causally relevant, we began to reconceptualize some of the most basic physical processes in terms of the concept of constraint: Properties and the degrees of freedom not actualized. This **figure/background** reversal didn't undermine any

known physical principles, nor did it introduce novel, unprecedented physical principles or special fundamental forces into contemporary science … in order to account for what prior physical intuition seemed unable to explain about meaning, purpose or consciousness. Rather, it merely required tracing the way that two levels of self-organizing, constraint-creating processes could be so entangled as to result in a dynamical unit an autogen or teleogen that enables specific constraints to create, preserve, and replicate themselves with respect to the given constraints in their physical context. But being able to trace in every detail each step that is required to cross from the realm of simple mechanical processes in the realm of entential relationships **changes everything**. Even such basic concepts as work and information have taken on new meaning, and previously esoteric notions like self and sentience can be given fairly precise physical definitions (p. 540, my bolding).

Another potential influence on Deacon was McLuhan's notion of the reversal of cause and effect. Deacon asks what happens when a thought results in an action? "The thought is about a possibility, and a possibility is something that doesn't yet exist and may never exist. It is as though a possible future is somehow influencing the present (p. 21)." This is analogous to an idea of McLuhan's expressed in a letter to Ashley Montague, "I feel compelled to consider causation as following effects. The effects of the telegraph created an environment of information that made the telephone a perfectly natural development [11]."

Deacon returns to this notion of the reversal of cause and effect when he writes,

Being organized for the sake of achieving a specific end is implicit in Aristotle's phrase "final cause". Of course there cannot be a literal ends-causing-the-means process involved, nor did Aristotle imply that there was. And yet there is something about the organization of living systems that makes it appear this way. This time-reversed appearance is a common attribute of living processes, albeit in slightly different forms, at all levels of function (p. 109).

I see a parallel in McLuhan's quip "I would not have seen it if I didn't believe it" and the following Deacon remark regarding the perception of regularity.

"To even perceive regularity or pattern this act of observation itself must be grounded in a habit of mind, so to speak. In other words, to attribute physical regularity to some perceived or measured phenomenon presumes a prior mental regularity or habit with respect to which the physical regularity is assessed (p. 189)."

I also see another McLuhan-Deacon parallel with McLuhan's one-liner "the user is the content" and Deacon's "computation is in the mind of the beholder, not in the physical process (p. 525)." I am in complete agreement with Deacon on this point, as I have made clear in my article, "What is information?", in this collection of essays [12] when I wrote, "The knowledge and intention of the sender and the receiver as well as the effects of the channel all affect the meaning of the message that is transmitted by the signal in addition to its content."

10. Deacon's Description of Information and Its Interpretation

Deacon associates information with constraints making reference to Kauffman, Logan, et al. [7], where we developed the notion that information and constraints are intimately connected. Deacon quotes an excerpt from that paper as the result of a private communication from Stuart Kauffman.

"The first surprise is that it takes constraints on the release of energy to perform work, but it takes work to create constraints. The second surprise is that constraints are information and information is constraint. (ibid. quoted on page 392 of Deacon's text [1])."

The connection between information and constraints arose in an amusing way in a conversation between Kauffman and myself and in part was due to the influence of Marshall McLuhan posthumously. Stuart Kauffman asked what is the nature of biological information and went on to point out as quoted above "that it takes constraints on the release of energy to perform work, but it takes work to create constraints. Where did the work come from to create the first constraints?" asked Stuart. I don't know I responded; but then in a playful semi-joking manner as McLuhan's one liner "the medium is the message" popped into my mind I said, "Hey Stuart, the constraints are the information." To my surprise Stuart said something to the effect, Bob you are right that's it. We have a lot of work in front of us and that gave birth to our paper The Propagation of Organization: An Enquiry [7].

An example of how Deacon connects constraints and information can be found in is his description of DNA:

> This retained foundation of reproduced constraints is effectively the precursor to genetic information (or rather the general property that genetic information also exhibits) …. whether it is embodied in specific information-bearing molecules (as in DNA) or merely in the molecular interaction constraints of a simple autogenic process, information is ultimately constituted by preserved constraints (pp. 317–318).

I [12] also concur with Deacon when he explains that the popular notion of information is confused because it is conflated with energy and it is thought of as a thing (a noun) and not as a process, (a verb). One does not obtain information; one is informed (Malcolm Dean private communication).

> Information is "a dynamic relational" thing. Thinking of energy as a substance parallels an 18th and early 19th century notion that energy was a substance (p. 333).

> The current era is often described as "the information age", but although we use the concept of information almost daily without confusion, and we build the machinery (computers) and networks to exchange, analyze, and store it, I believe that we still don't really know what it is (p. 371).

> Bateson was reacting against the misleading metaphorical use of energetic concepts to talk about informational processes …. This misleading conflation of energy with information often leads us to treat information as though it is a physical commodity; a kind of stuff that one can acquire, store, sell, move, lose, share and so on (p. 333).

> Information is a relational property that emerges from nested layers of constraint: constraints of signal probability (Shannon), constraints of the dynamics of signal (Boltzman), and the constraints required for self-maintaining, far-from-equilibrium, end directed dynamics (Darwin) (p. 418).

I [12] also agree with Deacon's observations that information has many different faces and that Shannon information has its shortcomings as when he writes,

The concept of information is a central unifying concept in the sciences. It plays critical roles in physics, computation and control theory, biology, cognitive neuroscience, and of course the psychological and social sciences. It is, however, defined somewhat differently in each, to the extent that the aspects of the concept that are most relevant to each may be almost entirely non-overlapping. The most precise technical definition of information has come from the work of Claude Shannon, who in the 1940s made precise quantitative analysis of information capacity and transmission possible. As we will see, however, this progress came at the cost of entirely ignoring the representational aspect of the concept that is its ultimate base (p. 372).

My favorite Deacon descriptions of information are the following because they parallel my view that the meaning of information is determined by the receiver and what the sender sends are signs not information. This is because information is not a thing, it is a process.

Although almost every physical difference in the history of the universe can potentially be interpreted to provide information about any number of other linked physical occurrences, the unimaginably vast majority of these go uninterpreted, and so cannot be said to be information about anything (p. 392).

A DNA molecule outside an organism does not convey information about anything, and is mostly just sticky goo …. Calling it [DNA] the "secret of life" is thus hyperbole (pp. 437–438).

What makes it information about anything rather than just a simple physical influence? Clearly, it is the process of interpretation that matters (p. 395).

This last quote of Deacon's parallels McLuhan's famous one-liner: "the user is the content", which following Deacon we can reformulate as "the interpretation is the content".

11. Consciousness

Deacon does not dodge the most challenging questions of science as evidenced by his taking on the question of consciousness that many scientists have given up on as not amenable to scientific inquiry. Not Terry Deacon who writes,

Conscious experience confronts us with a variant of the same problem that we face with respect to function, meaning, or value. None of these phenomena are materially present either and yet they matter …. But there is an additional issue with consciousness that makes it particularly insistent, in a range these other absential relations are not: *That which is explicitly absent is me*.

Reframing the concept of sentience in emergent dynamical terms will allow us to address questions that are not often considered to be subject to empirical neuroscientific analysis. Contrary to many neuroscience colleagues, I believe that these phenomena are entirely available to scientific investigation once we discover how they emerge from lower-level teleodynamic, morphodynamic and thermodynamic processes (p. 487).

The locus of subjective sentience is not, in fact, a material substrate. The riddle was not the result any problem with the concept of consciousness, but of our failure to understand the

causal relevance of constraint. With the realization that specific absent tendencies—dynamical constraints—are critically relevant to the causal fabric of the world, and are the crucial mediators of non-spontaneous change, we are able to stop searching for consciousness "in" the brain or "made of" neural signals (p. 534).

As Tom Wolfe said of McLuhan, what if he (*i.e.*, Deacon) is right. While Deacon has not solved the problem of consciousness by his own admission he has certainly identified what seems to be a fruitful direction in which to look for the ultimate solution to the riddle of human consciousness.

Not only does Deacon take on the problem of consciousness; he also tackles the question of what is emotion.

> In cases of life-and-death contexts, morphodynamic change must be instituted rapidly and extensively at both the homeodynamic (metabolic) and morphodynamic (mental) levels. The extent of this work and the intensity of the tension created by the resistance of dynamical change is, I submit, experienced as the intensity of emotion (p. 527).

> The capacity to suffer requires the higher-order teleodynamic loop that brain processes make possible (p. 528).

12. Are Language, Culture, Technology and Science Teleodynamic Phenomena?

The following passage of Incomplete Nature raised the following question in my mind are language, culture, technology and science teleodynamic phenomena?

> Teleodynamics can be understood as characterizing the distinguishing dynamics of life. However, rather than being an abstract description of the properties that living processes exhibit, it is a specific dynamical form that can be described in quasi-mechanical terms. Although it is the distinguishing characteristic of living processes, it is not necessarily limited to the biological. Teleodynamic processes can be identified with respect to the specific end-directed attractor dynamics they develop toward (p. 275).

So why do I think that language, culture, technology and science (LCT&S) represent teleodynamic processes? I believe that they are autonomous agents that maintain themselves, self-organize, and seem to have agency? They are obligate symbionts and hence their energy is provided by their hosts, us humans, but they assist their hosts acquire energy and do work.

The following description of Deacon of the processes of living organisms seems to apply with almost equal validity to LCT&S.

> We find processes [for both living organisms and LCT&S] that (a) consistently partition thermodynamic processes so that many components processes follow trajectories that run radically counter to global thermodynamic probabilities; (b) are highly heterogeneous in structure and dynamics; (c) produce processes/behaviors that are so convoluted, divergent, and idiosyncratic as to defy compact algorithmic description; (d) generate and maintain aggregate systemic properties that are quite distinct from any properties of the components, and (e) reflect the effects of deep historical contingencies that may no longer be existent in their present context (p. 267)".

Language, culture, technology and science (LCT&S) do not (a) directly counter thermodynamic dissipation but they are the tools that enhance human's ability to do so. There is no question that (b) they are heterogeneous in structure and dynamics and that (c) they defy a compact algorithmic description. They certainly (d) have systemic properties not possessed by their components. They are emergent phenomena and (e) they reflect the effects of deep historical and pre-historical contingencies.

Not only do LCT&S parallel the processes of living organisms they also undergo a parallel form of Darwinian evolution of descent, modification and selection. "The process of evolution, rather than merely maintaining and reproducing dynamical form, exhibits a spontaneous tendency for its dynamics to diversify and complexify these forms, both intrinsically and in their relationship to their contexts (p. 275)." This description fits both living organisms and LCT&S.

"The incessant need [of living organisms] to replace and reconstruct organism components depends on synthetic form-generating processes, not merely resistance to breakdown (p. 276)." LCT&S also in a certain sense replace and reconstruct their components through form-generating processes (new words, cultural practices, technological principles and theories respectively). Like living organisms they are also self-correcting and self-maintaining.

Reproduction of life is "the construction of a dynamical physical system, which is a replica of the system that constructed it, in both its structural and functional respects, though not necessarily a faithful replica in every detail (p. 278)." This is also true of LCT&S. Each reproduces itself from generation to generation just like life.

"Life requires the constant acquisition of energy and raw materials from its environment, and an incessantly active, tightly orchestrated use of these to stay ahead of the ravages of thermodynamic decay (p. 280)." LCT&S acquire their energy from their hosts, as they are obligate symbionts that repay their hosts by increasing their host's ability to acquire energy and other resources that promote their well-being.

Deacon also suggests that "teleodynamic systems" [can be] found in ecosystems, complex organisms, brains, and even social systems". I take this as support of my extension of Deacon's program to explicitly contend that language, culture, science and technology (LCT&S), which are social systems, are also teleodynamic systems that are "self-creating, self-maintaining, self-reproducing, individuated systems (p. 325)".

13. Conclusions

Terry Deacon has treated the readers of his book to an extraordinary journey of ideas that are at the same time scientific, philosophical and ethical. Ultimately to my mind one of the great contributions of his book is that he has provided a mechanism and a language for talking scientifically about that, which is most dear and most critical to human existence and its sustainability on this planet, namely value.

As Deacon points out despite all the achievements of science to understand our physical universe science has

> at the same time conceived the realm of value as radically alienated from this seeming
> complete understanding of the fabric of existence …. The removal of any approach to

value from a scientific perspective is the ultimate expression of having accepted the presumed necessity of that elective surgery (p. 544).

And I as a scientist, a trained physicist, now feel brave enough to make a value judgment that is both subjective as a humanist and objective as a scientist, namely, that there is great value in Deacon's book for the field of science. We must include value in our deliberations of science and I thank Terry for his book and for making this point so clearly from both a scientific and a humanistic perspective.

References and Notes

1. Deacon, T. *Incomplete Nature: How Mind Emerged From Matter*, 1st ed.; Norton: New York, NY, USA, 2012.
2. The number in parentheses represents the page in Deacon's book where this quote comes from. This convention will be used throughout the review.
3. Kuhn, T. *Structure of Scientific Revolutions*, 1st ed.; University of Chicago Press: Chicago, IL, USA, 1962.
4. Maturana, H.; Varela, F. *Autopoiesis and Cognition: The Realization of the Living*, 1st ed.; D. Reidel: Dordrecht, the Netherland, 1980.
5. Kauffman, S. *The Origins of Order: Self-Organization and Selection in Evolution*, 1st ed.; Oxford University Press: New York, NY, USA, 1993.
6. Kauffman, S. *Investigations*; Oxford University Press: New York, NY, USA, 2000.
7. Kauffman, S.; Logan, R.K.; Este, R.; Goebel, R.; Hobill, D.; Shmulevich, I. Propagating organization: An enquiry. *Biol. Philos*. **2007**, *23*, 27–45.
8. Wiktionary home page. Available online: http://en.wiktionary.org (accessed on 31 July 2012).
9. Logan, R.K.; Schumann, J. The symbolosphere, conceptualization, language and neo-dualism. *Semiotica* **2005**, *155*, 201–214.
10. Logan, R.K. *The Alphabet Effect*, 2nd ed.; Hampton: Cresskill, NJ, USA, 2004.
11. McLuhan, M.; McLuhan, E. *Media and Formal Cause*; NeoPoiesis Press: New York, NY, USA, 2011.
12. Logan, R.K. What is information? Why is it relativistic and what is its relationship to materiality, meaning and organization. *Information* **2012**, *3*, 68–91.